For color images, the watermarking procedure is essentially the same, except that the linear brightness Y of each pixel to be altered typically must be extracted from some combination of the component samples. In an r/g/b image Y is a linear combination of the linearized red, green, and blue components; in a y/cb/cr image Y is the y component with appropriate linearization applied. The procedure for color images is shown in FIG. **5**.

In step **502**, each pixel component is converted to a linear brightness scale, if necessary. The perceptually uniform brightness of the pixel is calculated from the result using Equation 2.

Next, steps **304** through **310** are performed in the same manner as for a monochrome image to determine the scaling factor S'.

Next, in step **504** the linear intensity of each pixel component is multiplied by S'.

Then, in step **506** the results are converted back to the nonlinear pixel component value ranges, if desired.

Many other variations and enhancements of the basic method are possible. For example, the noise component may be based on an element of a reproducible (ciphered) random sequence, or a noise sequence created by a ciphered key, rather than on a random number; in this case a system for removing the watermark if the watermark image and cipher key are provided could be designed. In a second variation, the decision whether to brighten or darken a pixel could be based on whether its luminance is above or below some arbitrary threshold: brighter pixels could be darkened and darker pixels could be brightened. This would make it more difficult to tell, for pixels near the threshold, which side of the threshold they started on, making the watermark more difficult to remove, and it would make it possible to ensure that the watermark will be visible on backgrounds of any intensity. This method could be further modified by picking the threshold adaptively, e.g., by taking the median of a small region around the pixel to be watermarked and ensuring that the threshold is not close to that value. As another variation, the watermark can be made more difficult to remove by varying the size, position and/or brightness of the watermark and/or intensity of the random noise, from one original image to the next.

Now that the invention has been described by way of the preferred embodiment, various modifications and improvements will occur to those of skill in the art. Thus, it should be understood that the preferred embodiment has been provided as an example and not as a limitation. The scope of the invention is defined by the appended claims.

What is claimed is:

1. A method of placing a visible watermark on a digital image, comprising the steps of:

providing a digital original image;

providing a digital watermark image; and,

producing a watermarked image by superimposing the watermark image on the original image without changing the chromaticities of pixels of the original image as watermarked.

2. The method of claim **1** wherein the producing comprises the steps of:

for each pixel in the watermark image that is not "transparent", modifying the corresponding pixel of the original image by changing the brightness but not the color.

3. A method of applying a digital watermark to an original image comprising the step of applying the watermark to the original image as a multiplicative correction on pixel sample values of the original image in a linear color space such that the chromaticities of the pixels are not changed.

4. A system for placing a visible watermark on a digital image, comprising:

a storage device having a digital original image and a digital watermark stored therein; and,

means for producing a watermarked image by superimposing the watermark on the original image without changing the chromaticities of the original image as watermarked.

5. The system of claim **4** wherein the means for producing comprises:

means for modifying each pixel of the original image corresponding to a non-transparent watermark pixel, by changing the brightness but not the color.

6. A system for applying a digital watermark to an original digital image, comprising:

means for identifying a subset of pixels of the original image that will be modified as a result of applying the watermark;

means for determining a scaling value based on the values of the color components for each of the pixels in the subset,

means of multiplying each of the color components of each of the pixels in the subset by its scaling value, and

means for storing a resulting watermarked image.

7. A system for applying a digital watermark to an original digital image, comprising:

means for identifying a subset of pixels of the original image to be modified as a result of applying the watermark;

means for linearizing the color components of each pixel in the subset,

means for determining a scaling value based on the linearized values of the color components for each pixel in the subset,

means of multiplying each component of each pixel in the subset by its scaling value, and

means for delinearizing the modified components of each pixel in the subset, and

means for storing a resulting watermarked image.

8. The system of claim **7** wherein said means for determining a scaling value S is responsive to a random noise field.

9. The system of claim **7**, wherein said means for determining a scaling value S is responsive to an element of a reproducible random sequence, or a noise sequence created by a ciphered key.

10. The system of claim **7** wherein said means for determining a scaling value S is responsive to the value of a corresponding watermark pixel.

11. A method for applying a digital watermark to an original digital image, comprising the steps of:

identifying a subset of pixels of the original image to be modified;

for each pixel in said subset of pixels,

determining a scaling value based on the values of the color components of said pixel; and,

multiplying each component of said pixel by said scaling value S, and,

storing a resulting watermarked image.

12. The method of claim **11** comprising the further steps of: prior to the determining, linearizing the color components of said pixel; and, subsequent to the multiplying, delinearizing modified components of said pixel.

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